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APPLIED RESEARCH LABORATORIES

# THE UNIVERSITY OF TEXAS AT AUSTIN

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## NEXT GENERATION DEPTH SOUNDER

Quarterly Progress Report No. 1 under Contract N00024-74-C-1069, Item 0024
27 September - 27 December 1973

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B. Paul Guyton

NAVAL SHIP SYSTEMS COMMAND
Contract N00024-74-C-1069, Item 0024



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THE UNIVERSITY OF TEXAS AT AUSTIN
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## ABSTRACT

The first part of this report describes Applied Research Laboratories (ARL) continued assistance to NAVSHIPS PMS 302-242 with technical monitoring of the AN/UQN-1,4 retrofit kit procurement. Preproduction performance testing of the kit was observed at Honeywell, Inc., in Seattle, Washington, and a program review was attended.

The second item covers work on developing a high frequency transducer for the Next Generation Depth Sounder (NGDS), which began on 1 October 1973. Two preliminary designs are to be tested. One is a 7-element mosaic of 7/8 in. ceramic discs arranged in a circular pattern, with a center element surrounded by six outer elements. The other is a 3 in. diam ceramic disc that is diced by cutting part way through the element on a rectangular grid pattern.

A housing for these elements will consist of a standard AN/UQN-4 transducer housing that will also contain six mass-loaded 12 kHz elements of a type already used by the AN/UQN-4. The 12 kHz elements will surround the centrally located high frequency element.

Work began on developing a signal processor for the NGDS on 1 December 1973. Preliminary efforts have been directed toward obtaining acoustic signal and noise data from AN/UQN-4 depth sounders to ascertain the operating environment within which the signal processor must function.

TABLE OF CONTENTS

ITEM 0024, A: DEPTH SOUNDER DEVELOPMENT PROGRAM
E. Blum

# I. INTRODUCTION

As a part of the depth sounder development program, ARL will continue to participate in the AN/UQN-1,4 Retrofit Kit Program. This program is a continuation of work that was reported under Contract N00024-73-C-1127, and consists of assistance to NAVSHIPS PMS 302-242, with technical monitoring of the retrofit kit procurement and coordination of the government's preproduction testing effort. Included here is the work of Dr. V. Salmon of Stanford Research Institute (SRI) as a technical advisor under ARL Subcontract N91662-73-C-0003.

## II. HONEYWELL, INC., PREPRODUCTION PERFORMANCE TESTING

Honeywell, Inc., Marine Systems Center, subjected the retrofit kit preproduction model to required performance testing during the period 2-5 October 1973. Mr. E. Blum (ARL) attended these tests for the purpose of learning Honeywell's testing techniques. The knowledge gained will be used to help evaluate the results of both Honeywell's and the government's preproduction testing. The details of this survey were recorded in ARL ltr Ser E-299 of 8 October 1973. Noted in this letter is the absence of raw data on the preproduction test data sheets. The data sheets indicate only that the transducer meets the contract specifications, but they do not indicate the real characteristics of the transducer.

## III. PROGRAM REVIEW

On 30 October 1973, review of the AN/UQN-1,4 Retrofit Kit Program was held at Honeywell, Inc., Marine Systems Center, Seattle, Washington. The meeting was attended by Mr. Blum, Mr. T. Nugent from NAVSHIPS, Mr. M. Hickman from DCAS, and Messrs. G. Cash, J. Billings, and R. Meyer from Honeywell, Inc. Details of this meeting were recorded in ARL ltr Ser E-333 of 7 November 1973.

Both performance and environmental tests were carried out and the retrofitted transducer met and exceeded all performance specifications. At high pressure-high temperature, the transducer exhibited high level impedance characteristics that were significantly out of specification during the environmental testing. Honeywell presented a troubleshooting procedure which was generally accepted by those present. The unit had apparently passed the other environmental tests. It was discovered in October that delivery of the first article would be delayed at least until the end of January 1974.

Honeywell presented ARL with a nonhardened, copper-nickel window. It was a nondeliverable item, and since Honeywell had planned to discard it, ARL accepted the window for experiments relating to the Next Generation Depth Sounder.

Although ARL did not actively participate in the Retrofit Kit Program during November and December, it might be noted that the delivery date of the preproduction transducer was postponed again, this time until the end of February. It was also noticed during these months that some of the elements may have been injured during the shock tests. The extent of this damage is still not known.

## IV. VISIT TO STANFORD RESEARCH INSTITUTE

A brief meeting was held 1 November 1973 at SRI to review retrofitted transducer failure data. Dr. Salmon was unable to attend, but Mr. Blum and Mr. E. M. Spurlock of SRI discussed the problems in detail. Also, SRI presented to ARL the silicone oil filled system used originally with the experimental model retrofit kits. ARL accepted this laboratory bench system for use in the new generation transducer effort.

ITEM 0024, B: NEXT GENERATION DEPTH SOUNDER STUDIES
P. Guyton and J. Hocker

## I. INTRODUCTION

Investigation of the design of a high frequency transducer for the Next Generation Depth Sounder (NGDS) was begun on 1 October 1973. The objective of this work is to design a dual frequency transducer that is contained within a standard AN/UQN-4 transducer housing. The low frequency transducer will consist of 12 kHz mass-loaded elements of the type already used in some versions of the AN/UQN-4 transducer. The high frequency transducer will be a new design and will operate at 120 kHz.

Investigation of a signal processor for the NGDS was begun on 1 December. The objective of this work is to ascertain what signal processing is required to generate a reliable digital depth indication.

## II. HIGH FREQUENCY TRANSDUCER

Two means of providing a low and high frequency transducer in the same housing have been considered. In one approach, a high frequency transducer would overlay the faces of mass-loaded low frequency elements and comprise part of the low frequency elements' mass loads. This design, as shown by the cutaway pictured in Fig. 1, is currently used by the AN/BQN-17 transducer. In the other approach, the center element in a 7-element configuration of the AN/UQN-4 transducer would be replaced by a high frequency element. For ease in modifying existing AN/UQN-4 transducers the second approach is preferred. It remains to be seen whether or not removal of the center from the 12 kHz array will excessively degrade the transducers' low frequency performance. However, studies during the AN/BQN-17 development indicated that low frequency degradation will not be a problem, so it is hoped this configuration can be used. Assuming success in replacing the center element, the more complex mass-loaded transducer of the AN/BQN-17 type will not be investigated further.

The AN/UQN-4 currently uses transducers in the AT-200 series, versions A through G, and several nonmagnetic transducers that were developed for AN/UQN-4 use on minehunting ships. In addition, a retrofit kit for AN/UQN-4 transducers is now being tested. This retrofit kit contains a copper-nickel window in conjunction with a pressure compensation system, and a new 12 kHz element in a design that is less subject to external damage than the rubber window design of most of the earlier versions of the AT-200 series. Of these existing AN/UQN-4 transducers, only the ones containing 7 elements are being considered in this study for high frequency modification. These include the AT-200 F and G versions and the new retrofit design.

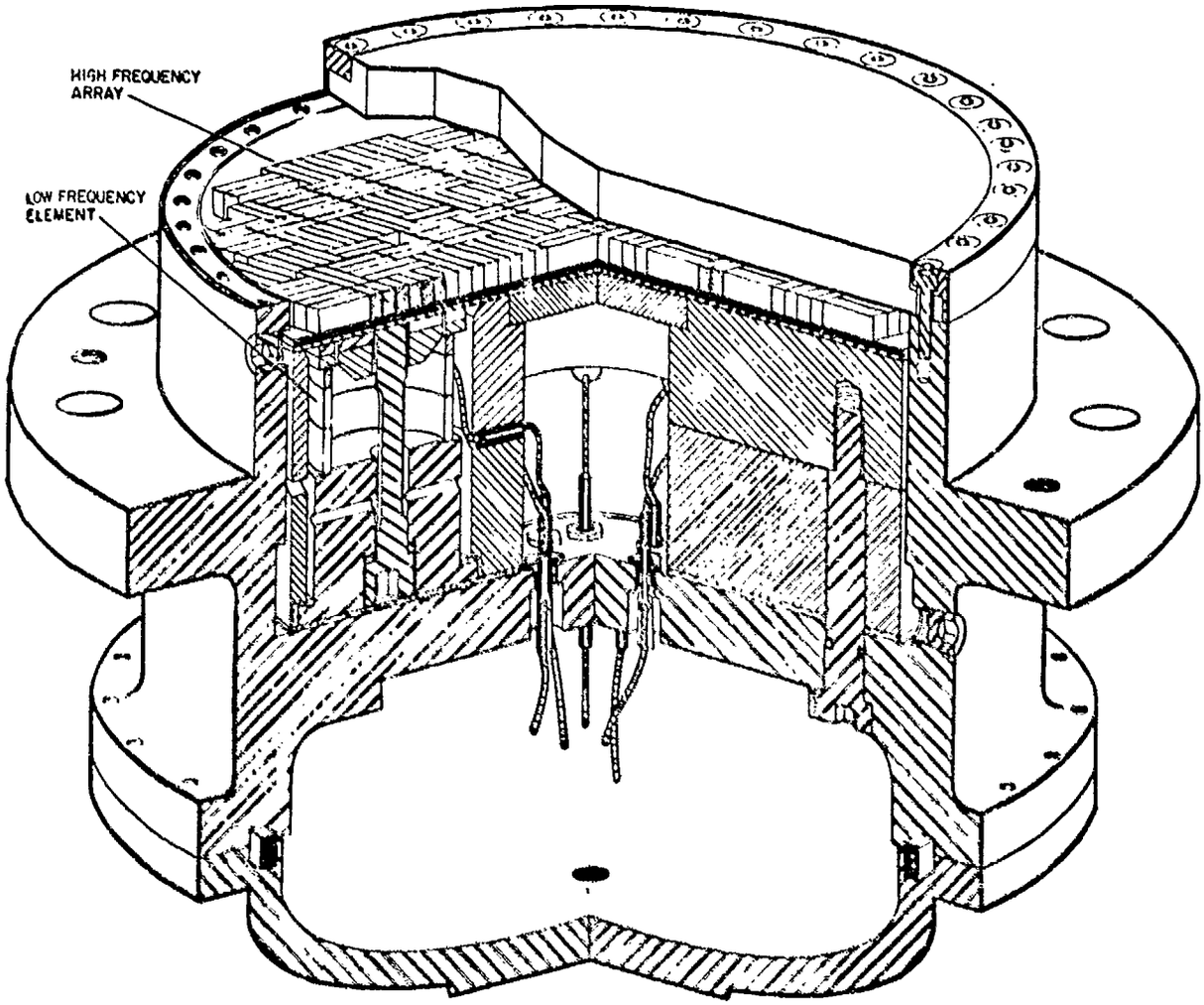


FIGURE 1
AN/BQN-17 (XN-1) TRANSDUCER CUT-AWAY VIEW

A major concern is the attenuation of the retrofitted copper-nickel window at high frequency. Previous tests at ARL on the AN/BQN-17 transducer indicated that a copper-nickel window of approximately 1/4 in. thickness attenuates the signal in excess of 13 dB at the high frequency of the AN/BQN-17. The 120 kHz high frequency presently proposed for the NGDS is considerably lower than the AN/BQN-17 high frequency; however, excessive attenuation may still be caused by the retrofit kit's copper-nickel window. If excessive high frequency attenuation does occur with the retrofit transducer, modification of the window may be required. The modification could be by replacing the complete window with an engineering plastic material or by providing for a smaller window of rubber or plastic within the center of the copper-nickel window for the high frequency element. An alternate approach could also be to adapt the high frequency transducer only to the AT-200 F or G models, which do not have copper-nickel windows.

The initial tasks in the transducer development are to ascertain the high frequency attenuation of the retrofit kit copper-nickel window, to determine the extent of performance degradation at 12 kHz when the center element is eliminated,and to design a suitable high frequency element.

The four prototype units used by SRI and NSRDC for prototype retrofit kit tests were received in December for use by ARL in the first two tasks. Only one of the four will be selected for modification. The element size for these prototypes is 2 3/4 in. in diameter versus the 3 in. element diameter of the production retrofit kits. However, attenuation and degradation characteristics should not differ significantly since the size differences are so small. After the production retrofit kits have completed government acceptance tests, a production retrofit kit transducer is to be made available to ARL for testing of the high frequency modification.

Impedance tests were run in December on the prototype transducers as received. The Raytheon prototype transducer, shown in Fig. 2 with the window removed, was selected for further study because it utilizes a solid construction element holder in a poker chip configuration and a pressure compensation system in a design very similar to the production retrofit transducer. The Raytheon transducer impedance (series equivalent) was measured to be $(327 - j\ 170)\Omega$, which is easily tunable to the standard AN/UQN-4 transducer impedance of 150 $\Omega$ real.

Efforts were also made to ascertain cavitation limits of the Raytheon transducer as received; however, distortions in current and voltage waveforms occurred before cavitation limits were reached. The problem has been traced to saturation of the matching transformer used in the tests. A new transformer is being made for further cavitation tests of the 7-element configuration, which will be followed by cavitation tests of the 6-element configuration. Preparations are also being made to obtain beam patterns and sensitivities of the Raytheon retrofit transducer in both the 6- and 7-element configurations.

Two designs for the high frequency element are under consideration (1) a mosaic design consisting of seven circular disk elements with a 7/8 in. diam, arranged with a center element surrounded by six outer elements on a 15/16 in. radius, and (2) a 3 in. circular piston element diced by making straight cuts part way through the ceramic in two orthogonal directions. The dicing helps break up lower frequency resonant modes that otherwise can degrade performance when the element is driven. Sketches of the two configurations are shown in Fig. 3. The second configuration is preferred because of manufacturing ease and lower ceramic costs, but the first configuration will also be tested as a backup if the diced configuration does not prove satisfactory. Ceramic materials for both designs were ordered on 19 July 1973 but have not yet been received.

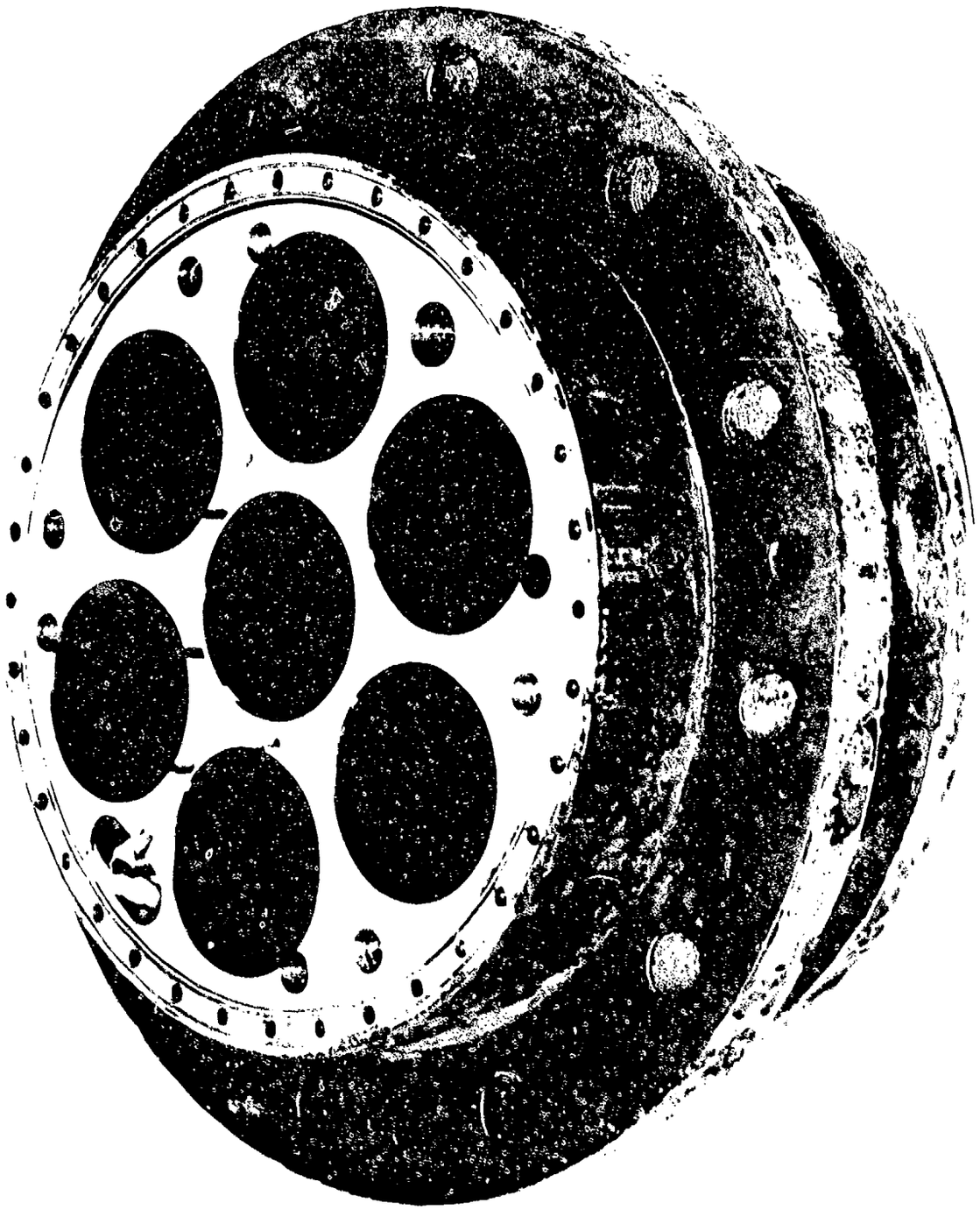

FIGURE 2
PROTOTYPE RAYTHEON RETROFIT TRANSDUCER

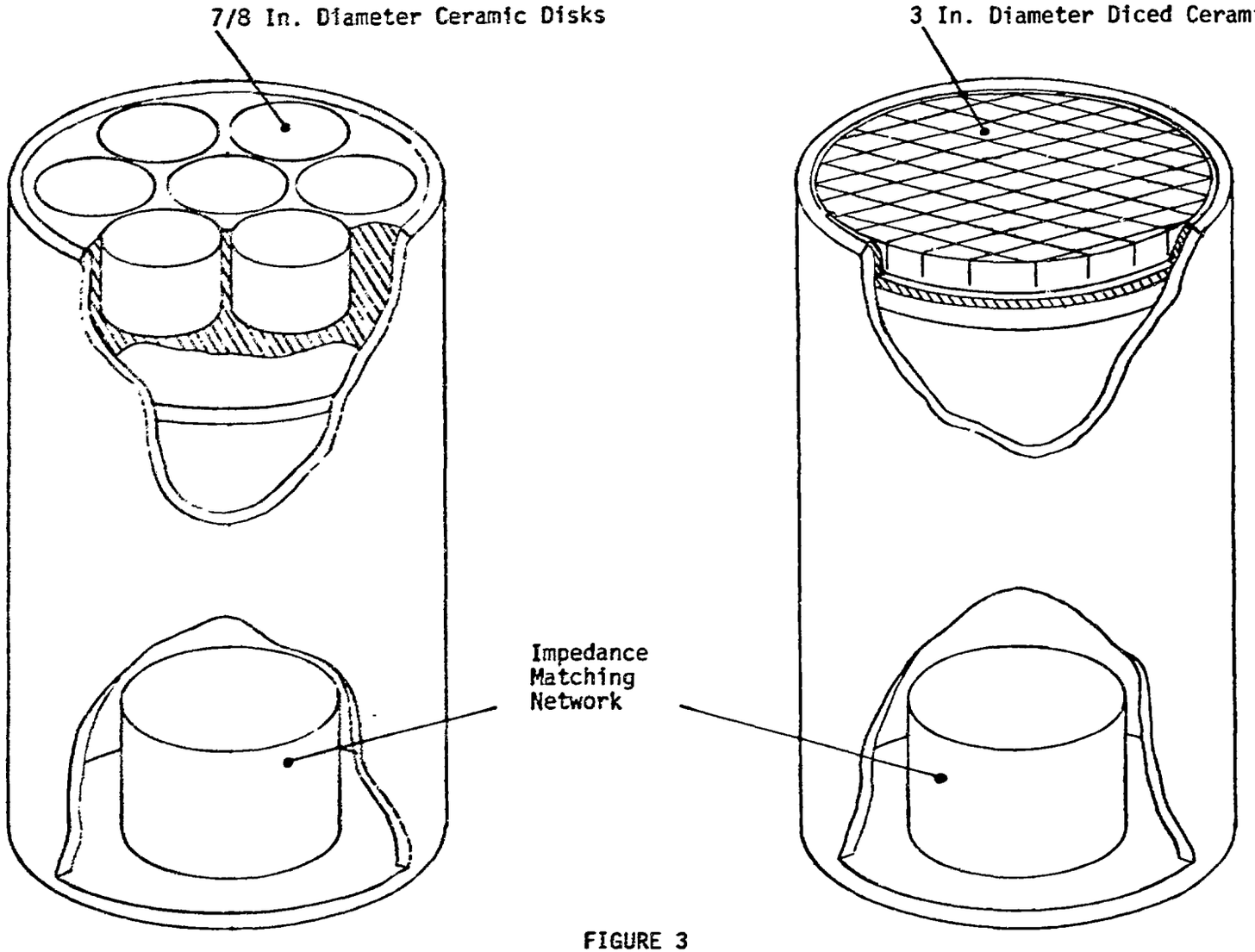


FIGURE 3

PROTOTYPE HIGH FREQUENCY ARRAYS

## III. SIGNAL PROCESSING

AN/UQN-4's in the past have not provided reliable digital depth readings because the depth readout tends to trigger prematurely on extraneous noise. Some form of signal processing is therefore needed to minimize these erroneous depth readings. The first step in solving this problem has been to seek data on what types and sources of acoustic signals cause trouble with the AN/UQN-4. The signal processor can then be tailored to discriminate against these extraneous signals. Three tapes of AN/UQN-4 data were provided to ARL by the Naval Underwater Systems Center (NUSC) at New London during a visit by representatives from NUSC on 11-12 December 1973. Analysis of these tapes is in process.

## IV. NUSC CONFERENCE

The general purpose of the 11-12 December conference was to discuss the status of the NGDS program and, in particular, to establish the ground rules for writing a specification for the NGDS. After program objectives were discussed, it was concluded that the NGDS should provide the following:

1. an accurate depth measurement referenced to the ship's keel,
2. suitable echo recognition to produce digital depth indication accurately to a digital display and/or to a digital interface,
3. hardware in functional packages to facilitate repairs and modifications, and
4. the above system capabilities, including the support package, within a $10K to $20K per unit price range.

Additional details of this meeting were provided in a conference report, ARL ltr SE-74-5.

8 March 1974

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